Article

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The detection of *Anaphes* sp. nov. [Hymenoptera : Mymaridae], an egg parasitoid of the carrot weevil in Nova Scotia

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The wasps *Anaphes victus* (Huber) and *Anaphes listronoti* (Huber) [Hymenoptera : Mymaridae] parasitize 50% of the eggs of carrot weevil, *Listronotus oregonensis* (Le Conte) [Coleoptera : Curculionidae] in Quebec and in Ontario. Attempts to detect either of these egg parasites from exposed carrot weevil eggs in Nova Scotia were unsuccessful. However, 48 individuals of a new species of parasitic wasp, *Anaphes* sp. nov. [Hymenoptera : Mymaridae], were detected in carrot (*Daucus carota*) fields in Nova Scotia, using carrots infested in growth chambers with carrot weevil eggs. *Anaphes* sp. nov. is distinguishable from the other parasites of the carrot weevil by characteristics of the forewing. *Anaphes* sp. nov. has a forewing length : width ratio greater than 7 : 3 while *A. victus* and *A. listronoti* have a forewing length : width ratio of less than 6 : 7.

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Les guêpes *Anaphes victus* (Huber) et *Anaphes listronoti* (Huber) [Hymenoptera : Mymaridae] parasitent 50% des oeufs du charançon de la carotte, *Listronotus oregonensis* (Le Conte) [Coleoptera : Curculionidae] au Québec et en Ontario. Des essais de piégeage en Nouvelle-Écosse de l'un ou l'autre de ces parasites en exposant des oeufs du charançon de la carotte n'ont pas réussi. Cependant, 48 spécimens d'une nouvelle espèce de guêpe, *Anaphes* sp. nov. [Hymenoptera : Mymaridae], ont été capturés dans des champs de carotte (*Daucus carota*) en Nouvelle-Écosse, en utilisant des carottes infestées en chambre de croissance par des oeufs du charançon de la carotte. *Anaphes* sp. nov. se distingue des autres parasites du charançon de la carotte par des caractéristiques de la paire d'ailes antérieure. *Anaphes* sp. nov. possède un rapport longueur : largeur plus grand que 7 : 3 pour l'aile antérieure alors que chez *A. victus* et *A. listronoti*, ce même rapport est plus petit que 6 : 7.

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The carrot weevil, *Listronotus oregonensis* (Le Conte) [Coleoptera : Curculionidae] is an important pest of vegetable crops in the northeastern United States and Canada (Collins and Grafius 1986). In Canada, this pest attacks parsley (*Pastinaca sativa* L.) and celery (*Apium graveolens* L. var. *dulce*) but is economically important only on carrots (*Daucus carota* L.), where up to 40% of the crop may be damaged if *L. oregonensis* is left uncontrolled (Boivin 1985; Perron 1971; Stevenson 1981). The carrot weevil was detected for the first time in 1992 in Nova Scotia (Le Blanc and Boivin 1993) where carrot production is increasing rapidly (Anonymous 1993).

Anaphes victus (Huber) and *A. listronoti* (Huber) [Hymenoptera : Mymaridae] are egg parasitoids which have a good potential as biological control agents against *L. oregonensis*. The former species is solitary, and the latter one is gregarious. Both species occur in eastern Canada and United States. Until now, these were the only parasitoids of carrot weevil eggs known and were collectively referred to as *Anaphes sordidatus* (Girault) (Boivin 1986); this latter species is presently considered to occur only in Wisconsin. These egg parasitoids have been identified as key factors in the control of the carrot weevil, being able to cause up to 50% mortality in field tests (Boivin 1986; Collins and Grafius 1986). In view of this fact and because *L. oregonensis* is a major pest in Ontario and Quebec, it was important to determine what parasitoids were affecting the eggs of the carrot weevil in Nova Scotia.

Carrots were infested with carrot weevil eggs in the laboratory by incubating adult carrot weevils with carrots in jars at 24°C under a 18-h light and 6-h dark photoperiod. With this technique, when *ca.* 300 carrot weevils (not sexed) were placed on four average size healthy carrots, about 50-300 eggs were laid over a period of 48 h on each carrot. The development of the weevil eggs was retarded by replacing the carrots every 2 d and refrigerating the infested carrots at 6°C until enough infested carrots were available for placement at the test sites. These eggs have been found to be acceptable by parasitoids and the development of the parasitoids is not affected (Traoré and Boivin, unpublished data).

During the late spring of 1994, six commercial carrot fields were selected as test sites near Great Village, Nova Scotia (lat. 45°25'N, long. 63°36'W). The sites were selected adjacent to the sites where weevils were detected the previous year (Le Blanc and Boivin 1993). Original sites of detection were not used because they were not currently sown to carrots due to crop rotation practices. Other significant carrot acreages are found near the New Brunswick border, in the vicinity of Oxford, Nova Scotia, (*ca.* 43 km due north of Great Village), where the main carrot processor is located.

At the end of each field, four 30 cm^2 wooden canopies were installed near overwintering sites of weeds and leaf litter favourable to carrot weevils. The carrots were protected from desiccation at the test sites by using these wooden canopies. Every week, a carrot infested in the laboratory with carrot weevil eggs was placed under each weather-proof canopy. The carrots were collected from the field after 3 d of exposure and in most cases, up to 25 *L. oregonensis* eggs were extracted from each carrot. Those eggs were incubated in polyethylene capsules (Boivin 1986) and the emergence of a weevil larva or a parasitoid was noted. This sampling was carried out each week from 29 April to 14 September, however, in two of the six commercial fields, monitoring carrots became useless because insect pest populations (including the carrot weevil) rose to a level requesting immediate insecticidal applications. Consequently the total egg potential of 12 000 was reduced to 7 200 and because the carrots were damaged, only 7 014 eggs were properly incubated.

On 6 June 1994, the first parasitoid emerged from one of the eggs exposed on 25 May. Thereafter, several other parasitoids emerged every week, the last ones emerging 22 August (Table 1). For validation purposes, some of the emerged parasitoids were examined and identified. Only one species was found. This parasitoid species was identified by Dr. J.T. Huber (Centre for Land and Biological Resources Research, Ottawa) as a new species of *Anaphes*. Several spe-

Table 1. Emergence of *Anaphes* sp. nov. from field exposed carrot weevil eggs in Nova Scotia carrot fields, summer 1994

Date of encapsulation	Date of emergence	Number of parasitoids
25 May	6 June	1
6 July	15 July	13
12 July	22 July	1
19 July	29 July	16
26 July	5 August	2
26 July	8 August	4
4 August	15 August	3
9 August	22 August	8

cimens were retained at this location as voucher specimens and for future research. This new species can be distinguished from *A. victus* and *A. listronoti* by characteristics of the forewing. *Anaphes* sp. nov. has a forewing length : width ratio greater than 7 : 3 while *A. victus* and *A. listronoti* both have a forewing length : width ratio of less than 6 : 7 (J.T. Huber, personal communication). A total of 48 egg parasitoids emerged from the 7014 eggs incubated during the study. Of the 6966 remaining incubated eggs, about 95% yielded a carrot weevil grub. The peak parasitism was observed on eggs encapsulated on 19 July, when 16 parasitoids emerged on 29 July from three of the six fields. Because there were four carrots placed in each field, on each sampling occasion (25 eggs carrot^{-1}) a simple percent parasitism can be calculated. It is obvious that many sampling occasions will result in no parasitism because eggs were made available before and after the optimal flight period of *Anaphes* spp. to maximize chances of detection. When the parasitoid was detected the percent parasitism ranged from 1.25% to 10.4%. Readers are cautioned not to interpret this percent parasitism as a valid reflection of field conditions. Our artificial system was strictly aimed at parasitoid detection and not quantification. In the same perspective, the sex ratio of *Anaphes* sp. nov., based on the total number of detected individuals, was 26♀ : 22♂. Statistically, this ratio was not found to be significantly different from 1 : 1 (χ^2 = 0.577, $\alpha = 0.05$, and one d.f.), however, this should be validated under natural field conditions.

The carrot weevil has recently been introduced in Nova Scotia and is consequently not a native host of *Anaphes* sp. nov. The indigenous hosts of *Anaphes* sp. nov. in the Maritimes are presently unknown. The egg parasitoids *A. victus* and *A. listronoti* were not detected at the test sites as expected, although they may be present at densities not detectable in this experiment. This is unlikely, however, due to the large number of eggs observed. Our results (up to 10.4% parasitism with this artificial system) suggest that *Anaphes* sp. nov. could be an important natural mortality factor for the carrot weevil, *Listronotus oregonensis*, in Nova Scotia, as other *Anaphes* spp. were found to be in Quebec and in Ontario (up to 50% parasitism). Consequently its activity should be considered in the development of an IPM programme and perhaps inundation releases should be carried out wherever carrot weevils are detected in Nova Scotia, particularly in new sites of our increasing carrot production.

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